DOCUMENT RESUME

ED 277 694 SP 028 480

AUTHOR DeGeeter, Marcia L.
TITLE An Annotated Bibliography on Learning for Mastery: Mastery Approaches To Improve Instructional Quality and To Increase Student Achievement.
PUB DATE Nov 86
NOTE 67p.; Exit project, Indiana University of South Bend.
PUB TYPE Reference Materials - Bibliographies (131) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Academic Achievement; *Educational Research; Feedback; *Instructional Improvement; *Learning Strategies; *Mastery Learning; Sequential Learning; *Teaching Methods; Time Factors (Learning); Tutoring

ABSTRACT

This annotated bibliography on mastery learning, intended for use by teachers, administrators, curriculum-planners, and researchers, covers writings and reports on the following topics: (1) research reports; (2) use of mastery learning concepts and strategies; (3) task skills analysis; (4) sequential learning; (5) learning hierarchies; (6) task structure--linking instruction and testing; (7) time on task; (8) feedback; (9) tutoring; (10) error analysis; (11) response patterns; (12) designs and strategies for computer-assisted instruction/computer-managed instruction systems; (13) support systems for mastery learning; and (14) testing/scoring systems. Most entries contain: (1) purpose of the study; (2) procedures and/or design of the study; and (3) major findings and/or conclusions of the research. A five-page "definitions of terms" is provided. Some conclusions are briefly stated, and suggestions are made for further research on mastery learning. (JD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED277694

An Annotated Bibliography on Learning for Mastery: Mastery Approaches to Improve Instructional Quality and to Increase Student Achievement

By

Marcia L. DeGeeter

Graduate Student

Study Directed By

Charles R. DuVall, Ph.D.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

M. L. DeGeeter

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

Submitted in partial fulfillment of the requirement

of S591 Research: Exit Project

Indiana University at South Bend

November, 1986

BEST COPY AVAILABLE

SP 028 480

TABLE OF CONTENTS

	Page
INTRODUCTION	1
STATEMENT OF THE PROBLEM AND PURPOSE OF STUDY	4
ORGANIZATION OF THE STUDY	6
LIMITATIONS OF THE STUDY	8
DEFINITIONS OF TERMS	9
ANNOTATIONS	14
Summary of Related Research	14
Use of Mastery Learning Concepts and Strategies	17
Process and Structure in Learning and Instruction	21
Task Skills Analysis	21
Sequential Learning	23
Learning Hierarchies	26
Task Structure: Linking Instruction and Testing	28
Time to Learn	30
Correctives	34
Feedback	34
Tutoring	35
Error Analysis	36
Response Patterns: Erroneous Use of Rules of Operation/Algorithms	36
Educational Technology	40
Designs and Strategies for Computer-Assisted Instruction/Computer-Managed Instruction	40
Support Systems for Mastery Learning Components and Strategies	42
Testing/Scoring Systems	43

Page

SUMMARY 45

CONCLUSIONS 53

RECOMMENDATIONS 54

BIBLIOGRAPHY 55

INTRODUCTION

This bibliography brought together some of the basic mastery ideas and some of the relevant supporting literature on mastery learning. It was intended for use by teachers, administrators, curriculum-planners, and researchers. For this reason, annotations were more detailed than necessary and included both empirical and theoretical readings which most clearly pointed out some of the fundamental concepts and variables to be considered when examining varying mastery learning approaches. Hopefully, the information presented will be of assistance to the reader in drawing implications, in posing questions, and in suggesting possible future research. The bibliography, however, was not designed to offer a complete summary of relevant literature. Therefore, for a more detailed presentation of the ideas provided, original sources should be consulted. To facilitate use of the bibliography, the following remarks have been offered to provide the reader with a brief survey of fundamental developments in mastery learning approaches.

Although the idea of learning for mastery had been introduced previously, effective mastery strategies have been developed only recently. During the late 1950's and early 1960's, mastery learning reappeared as a corollary of programmed instruction. Programmed instruction worked well for some students, especially those requiring small steps, drill, and frequent reinforcement. Even though this method helped some students

achieve mastery, it did not provide a useful model (Keller, 80; Bloom, 44-56). John B. Carroll's "Model for School Learning" presented school learning as consisting of a series of learning tasks. In each task, the student proceeded "...from ignorance of some specified fact or concept to knowledge or understanding of it or...from incapability of performing some act to capability of performing it" (Carroll, 723). Bloom transformed this conceptual model into an effective working model for mastery learning. According to Bloom, mastery learning provided almost all students with successful learning experiences. This powerful approach suggested that students could master what was taught and that the teaching-learning process could take place within the context of group-based classroom instruction. Furthermore, mastery learning was credited with enabling 75 to 90 per cent of the students to reach a high level of achievement. Bloom's mastery learning strategy, designed for the classroom, allowed for learning with a relatively fixed time allotment. The work of Robert Gagné (Gagné, Principles) provided procedures and categories for describing a unit's structure in terms of content to be learned and the cognitive processes used in learning that content. The structural descriptions provided a framework from which diagnostic tools could be built. Another major accomplishment to improve feedback and evaluation was developed by Peter W. Airasian in the late 1960's and early 1970's. His breakthrough was

designated formative evaluation and was designed to provide continuous feedback which enabled continued modification of the teaching-learning process with time variances so that each student could attain mastery (Airasian, "Modified," AEDS). Although much mastery learning research has continued, the findings provided in the annotated bibliography were as up to date as possible.

STATEMENT OF PROBLEM AND THE PURPOSE OF STUDY

The 1983 publication of A Nation at Risk: The Imperative For Educational Reform and the 1986 Carnegie Report were only two of the multitude of indicators in an outpouring of concern for the quality of American education in the 1980's. Despite great advances and determined efforts to improve our schools and student achievement, American education has reached a critical period in its history. Much has been accomplished. Course requirements have stiffened, new standards were adopted in most states, teachers' salaries increased, and re-examinations of the quality of teacher training programs have been initiated. Much more will be required, however. Studies clearly suggested that more research was needed to transform instruction into instruction of optimal quality for each learner rather than providing successful educational experiences for only about one-third of our students (Block, 3; Glaser, 924).

This study, then, was undertaken to identify mastery learning approaches of possible interest for school curriculum at all grade levels and in all classroom settings. Specifically, the research presented in this paper explored mastery strategies which emphasized student success in educational opportunities. Historically, mastery concepts and principles relevant to more contemporary strategies were provided for background and for a foundation on which to build. Variables of learning such as time, correctives,

task analysis, response patterns, formative evaluation, sequential learning, and educational technology were not only introduced but examined so others could draw implications from data presented, pose questions, and suggest new directions for future research and new applications of mastery learning strategies.

ORGANIZATION OF THE STUDY

The research material was divided into six major categories. Although some of the information overlapped, the research gathered was categorized into the area most relevant to the primary focus of the annotation. To facilitate use of the bibliography, the annotations were arranged according to the logical development of the argument with sub-categories systematically ordered within each of the three major categories. Within each categorized division, the annotations were listed alphabetically by author. An effort was made to follow a consistent form in the presentation of annotations. In so far as possible, each entry contained the following information: 1) the major purpose of the study; 2) the procedures and/or design of the study; and 3) the major findings and/or conclusions of the research.

The first part of the study presented a summary of research which supported mastery learning strategies and included background information as a base for understanding theory and operating procedures of mastery learning. Included in the second category were annotations focusing on models of learning and instructional design relevant to mastery learning concepts and strategies. The third major category described processes and structures in learning and instruction. Specifically, task skills analysis, sequential learning, learning hierarchies, and task structures that linked tests and instruction were also discussed. Comments stressing formative

evaluation were also included within many of the annotations. Research on time as it related to learning was presented in the fourth main division. Generally, time was analyzed as it related to specific review, to time spent on task, and to student ability. The fifth group of annotations described correctives and their relationships to improved student achievement. Discussed topics included feedback, tutoring, error analysis, and erroneous use of algorithms. Educational technology concluded the six categorized areas of research. Computer instruction, support systems, and testing/scoring systems as they related to mastery learning were discussed. Also included were innovative techniques and suggestions for teaching and learning.

LIMITATIONS OF THE STUDY

Research was limited by the time frame allowed for preparation and completion of the study. As a powerful idea affecting student achievement, mastery learning strategies and variations thereof have generated much school-based research and thus provided an unlimited scope when dealing with potential topics of interest in the field of education. Moreover, with the new approaches to learning, coupled with the fast-growing field of educational technology, mastery learning has merged past, present, and future educational research. Additionally, when focusing on the more modern techniques, knowledge was required of both previously used and up-to-date terminology. As a contemporary issue, available research became severely limited. Many studies were not completed and further research needed to be generated. In some instances, relevant studies were not available within a reasonable time period; and in other cases, the materials were not attainable.

DEFINITIONS OF TERMS

Academic Learning Time (ALT): "the amount of time a student spends engaged in an academic task that can be performed with high success by the student," (Seifert and Beck, Jr.: 6).

Adaptive Instructional System: an "instructional system... designed to provide...many programs of instruction ...to raise the performance level of as many different types of students as possible," (Stolurow: 16).

Adaptive Mastery Model: an instructional system which combines practice, formative evaluation, and remedial instruction with the amount of time varying for practice in accordance with attainment of the criterion (Taylor: 7).

Algorithm: a step-by-step procedure for solving a problem or accomplishing some end

Allocated Time: "...time available during school hours for a student to work on instructional objectives," (Seifert and Beck, Jr.,: 6).

Bugs: "precisely defined erroneous variations of a procedure," (Brown, "Repair Theory": 380).

Buggy: "a computerized game based on the diagnostic interactions of a tutor and a student," (Brown and Burton: 164)

Carroll's Model of School Learning: "a static model...using data to make a prediction about the level of success a student will achieve at the end of a period of instruction," (Stolurow: 9).

Computer-Assisted Instruction: instructional application of computers in supplementing traditional instruction (Hartley: 5).

Computer-Managed Instruction: "the computer...is used to monitor student progress through a series of instructional materials," (Hartley: 5).

Deep Structure: "set of buggy subprocedures that, when invoked, replicates those errors," (Brown and Burton: 161).

Developmental Theories of Learning: "the degrees of understanding can be expected to produce changes in kind of knowledge representation as well as in performance level," (Birenbaum and Shaw: 219).

Diagnostic Model: "a representation of a student's procedural knowledge or skill that depicts his internalization of a skill as a variant of a correct version of that skill," (Brown and Burton: 159).

Elapsed Time: both "the amount of time the student is involved in learning" and "the amount of time the student is not involved in learning," (Anderson, L.: 226).

Engaged Time: "...that part of allocated time during which the student is paying attention," (Seifert and Beck, Jr.: 6).

Forced Pacing: the monitored pacing in a personalized system of instruction (Taveggia: 1031).

Formative Evaluation: "the use of systematic evaluation in the process of curriculum construction, teaching, and learning for the purpose of improving any of these three processes," (Bloom: 117).

Forward Sequence: presenting elements at the lowest level of a learning hierarchy first and not moving forward until criterion for subordinate skills were attained (Trembath and White: 250).

Gagné's Learning Model: "conceives of school learning as a one-way progression from simple to increasingly complex learning tasks," (Stolurow: 10)

Generalization and Transfer: the application of previously learned information to new learning tasks or situations (Baker and Herman: 149)

Generative Theory of Bugs: "the set of principles and process that interprets" bugs, (Brown, "Repair Theory": 380).

Idiographic Model: "states that a computer can be used to control instruction in a dynamic interactive process," (Stolurow: 12)

Individual Learning Packets (ILP): a method of individualizing instruction in which varying amounts of material are contained within packets according to student needs (Hartley: 3-4).

Individualized Instruction: "the delivery system by means of which students become involved with the process of instruction," (Gagné, Principles: 185).

Instruction: "process of presenting stimulus sequences (and eliciting responses) designed to bring specified learner behaviors under the control of specific stimuli," (Resta: 1).

Instructional Management System: "the process of making decisions having, as its nucleus, specific empirically-verified rules for generating answers...in the form of prescription for specific educational actions to be taken by the teacher," (Resta: 2).

Instructional Monitoring System: a system which "provide(s) reporting capability" (Resta: 3).

Instructional Sequences: the "specific accomplishment of a single instructional objective must be preceded and followed by many other individual learning events," (Gagné, Principles: 99).

Intellectual Skill: "knowledge of how to perform some procedure that may be applied to a class of tasks," (White, "Understanding": 102).

Learning Hierarchy: "an arrangement of intellectual skill objectives into a pattern which shows the prerequisite relationships among them," (Gagné, Principles: 109).

Mark-Sense Reader: "a class of electronic devices that convert 'marks' made on a paper sheet to electronic information by means of either electrical or optical sensing of the marks," (Powell: 1).

Mastery Achievement: level of performance "concerned only with demonstration of the capacity to perform a single skill," (Trembath and White: 248).

Mastery Learning: strategy which proposed that all or almost all students could attain a mastery level achievement of what they were taught, (Bloom: 51).

Metacognitive Skills: "self-regulatory and self-management skills," (Glaser: 934).

Personalized System of Instruction (PSI): a mastery strategy of individualizing instruction created by Keller in 1965, (Keller: 79).

Procedural Network Model: "a collection of procedures with annotations in which the control structure between relationships are made explicit by appropriate links," (Brown and Burton: 159).

Productive Learning Hierarchy: the representation of an objective in which the learner both acquired and comprehended the skill (White and Mayer: 120).

Programmed Instruction: a method of individualizing instruction by presenting material in a step-by-step sequential manner (Hartley: 2)

Repair Theory: formalized theory "to explain the existence of many bugs...by making a clear distinction between incomplete procedures which are generated by mislearning or forgetting and the inventions that are necessary to account for certain bugs," (Brown, "Repair Theory": 414).

Response Pattern: systematic answering of items (Harnisch: 193).

Reverse Sequence: an ordering in which "learners came down the hierarchy until they reached skills they could do," (Trembath and White: 250).

Rule Assessment Approach: an approach that "can determine what rules an individual uses in performing a task as well as what rules are common to various groups of individuals and age groups," (Glaser: 929).

Summative Evaluation: "the type of evaluation used at the end of a term, course, or program for purposes of grading, certification, evaluation of progress, or research on the effectiveness of a curriculum, course of study, or educational plan," (Bloom: 117).

Systematic Errors: a procedure that produces incorrect responses (Brown, "Repair Theory": 380).

Task Analysis: "analyzing the structure of the desired objective and postulating a hierarchy and sequence," (Bloom: 26).

Task Specifications Chart (TSC): "a chart which integrates the content facets and the procedural steps of a specified task...for designing a test and interpreting its results," (Birenbaum and Shaw: 219).

Task Structure: "a model of the skills that are expected of the learner...(and)emphasis is upon what is to be learned," (Birenbaum and Shaw: 219).

Terminal Skill: "specification of how many times the learner has to demonstrate the skill before he is accepted as having learned it," (Trembath and White: 248).

Time-Off-Task: "...the amount of time the student is not involved in learning," (Anderson, L.: 226).

Time-On-Task: "time during which the student is actively involved in learning," (Anderson, L.: 228).

Time-To-Criterion: "the amount of elapsed time and the amount of on-task time to attain the criterion," (Anderson, L.: 226).

Traditional Non-Mastery Model: an instructional system with a fixed amount of practice and feedback and post-test (Taylor: 7).

Tutoring: "instruction by other students or aides," (Hartley: 5).

Typical Mastery Model: an instructional system with fixed amount of practice time and feedback followed by formative evaluation, remedial instruction, and a posttest (Taylor: 7).

ANNOTATIONS

SUMMARY OF RELATED RESEARCH

Block, James H., ed. Mastery Learning: Theory and Practice. New York: Holt, Rinehart and Winston, Inc., 1971.

This book presented articles which focused on the theory of mastery learning and necessary procedures to implement mastery learning strategies effectively. The ideas were described so that educators could use the information to pose questions for further research and new methods. Selected papers included articles by Benjamin S. Bloom, James H. Block, John B. Carroll, and Peter W. Airasian. Also included was an annotated bibliography of mastery learning strategies which were successfully applied in an effort to demonstrate the positive effect of this approach on student learning.

Bloom, Benjamin S., J. Thomas Hastings, and George F. Madaus. Handbook on Formative and Summative Evaluation to Student Learning. New York: McGraw-Hill Book Company, Inc., 1971.

This book, intended for teachers, was about evaluating learning in such a manner as to improve student learning and achievement. The first part of the book presented educational views and objectives, detailing ways to assist students in reaching mastery levels of learning. Next, the book described varying purposes of evaluation and how evaluation instruments could be designed for use in the classroom. The authors went on to explain models and techniques for designing valid evaluation instruments. Also provided were ways for instructors to reduce the evaluation workload. The second portion of the book discussed evaluation as it related to major fields of study. Basically, the work was a handbook designed to be used in a variety of teaching and learning situations.

Cronbach, Lee J., and Richard E. Snow. Aptitudes and Instructional Measures. New York: Irvington Publishers, Inc., 1977.

This book presented research on learning, instruction, and individual differences in ability to learn. It also proposed directions for further research. Detailed discussions examined how a person's characteristics influenced his responses to instruction. Topics discussed included the following: aptitude and instruction, learning rates as a reflection of aptitude, conceptualizing aptitude and treatments, cognitive skills, structures, and styles. A sufficiently comprehensive survey of literature and an evaluation of instructional measures were provided.

Glaser, Robert. "The Future of Testing." American Psychologist 36.9 (Sept. 1981): 923-36.

Glaser's article was a futuristic view of social and educational demands, of research relevant to cognitive development, and of performance measurement methods. In his juxtaposition of social-educational research requirements, the author explored three specific areas. First, Glaser described the shift from a selective educational system to a system designed to develop an entire population of educated people and one that placed emphasis on helping individuals succeed in educational opportunities. Although Glaser stressed the need for differential instructional practices which coordinated with useful diagnostic assessment, he advised that there had been little significant progress in this regard. Glaser added that diagnostic research of performance at varying levels of learning and development should contribute to assessment measures that would be useful for instructional decision and guidance. Next, the necessity for attaining high levels of competence and problem-solving skills was assessed. The last point of focus in Glaser's paper examined information processing models of aptitude and the acquisition of metacognitive skills necessary for further learning. Glaser also suggested that evaluation based on fundamental misconceptions influencing performance, not on the number of errors, was an important implication of research.

Hartley, Susan Strait. "Meta-Analysis of the Effects of Individually Paced Instruction in Mathematics." Diss. U. of Colorado, 1977.

Hartley's study was a summarization of the effects of individualized mathematics instruction to improve student performance. Computer-assisted instruction, cross-age and peer tutoring, individual learning packets, and programmed instruction were the methods examined and were restricted to individualized pacing. For the purposes of Hartley's study, definitions were included on each technique and related to those found in literature. Technique effectiveness was determined by comparing mathematics achievement attained by each method to that attained when students were taught in a conventional manner. Tutoring proved to be the most effective technique for achievement improvement. Additionally, computer-assisted instruction was more effective than programmed instruction. Programmed instruction was comparable to traditional instruction. Often, in fact, the traditional method proved more effective than the latter technique. Also provided was an analysis of relationships of effectiveness to a variety of variables of the differing instructional methods.

Popham, W. James, ed. Evaluation in Education. Berkley: McCutchan Publishing Corporation, 1974.

The contents of this book discussed current applications of evaluation in education and consisted of nine chapters, each written by a specialist in a theoretical or technical field about the topic under consideration. Michael Scriven discussed evaluation perspectives and procedures; Daniel L. Stufflebeam provided alternative approaches to educational evaluation; Peter W. Airasian presented summative evaluation studies; Richard M. Wolf considered data analysis; Gilbert Sax cited uses of standardized tests in evaluation; Jason Millman discussed criterion-referenced measurement information; Emil J. Haller wrote of cost analysis for program evaluations; Kenneth A. Sirotnik introduced matrix sampling; and Eva L. Baker discussed formative evaluation of instruction. No single approach to evaluation was presented. In fact, contributors disagreed, upon occasion, with each other on highly important topics in educational evaluation.

Rollins, Sidney P. "The Coventry, Rhode Island Mastery Learning Project." Education 104.2 (Spring 1979): 120-127.

Rollins briefly reviewed research studies relating to the effectiveness of mastery learning before introducing the project developed at The Coventry Junior High School. The problem posed was whether or not classes in which mastery learning components of a sequential curriculum evidenced a significantly higher achievement level than those classes in which mastery learning strategies were not employed. Conclusions drawn from the Coventry Project suggested that, with relative consistency, mastery learning resulted in greater improvement in achievement than did conventional approaches to instruction. Eighth grade science resulted in a .3325 per cent improvement for mastery learning and only a .1557 per cent improvement for non-mastery learning; seventh grade mathematics resulted in a .4412 per cent improvement for mastery and a .3193 per cent improvement for non-mastery; eighth grade mathematics resulted in a .598 per cent improvement for mastery learning and a .518 per cent improvement for non-mastery; seventh grade geography skills resulted in a .2517 per cent improvement for mastery learning and a .2513 per cent improvement for non-mastery learning; seventh grade geography content resulted in a .4841 per cent improvement for mastery learning and .2918 per cent improvement for non-mastery learning; and for seventh grade English, the data was incomplete. Some teachers were disappointed that resulting improvements were not more significant when considering the additional work and preparation required. However, students generally supported mastery learning because it afforded them a realistic opportunity to achieve basic skills and to accelerate to enrichment work rather than reworking materials mastered.

Taveggia, Thomas C. "Personalized Instruction: A Summary of Comparative Research, 1967-1974." American Journal of Physics 44.11 (Nov. 1976): 1028-33.

Taveggia summarized the results of studies comparing learning outcomes of conventional approaches with the learning outcomes of PSI, a personalized system of instruction. He stated that existing research literature suggested that the Keller Plan of PSI, a form of supervised independent study in which the materials were broken into sequential units, was preferred over traditional teaching methods. Emphasis on unit perfection, an extension of Skinnerian theory, provided reinforcement during evaluation and feedback. The unit perfection feature, monitored or forced pacing, and the use of proctors were major features which, according to Taveggia, probably accounted for the superiority of PSI. To master the unit perfection requirement, students had to pace their studies and eliminate cramming to succeed. Research further suggested that student learning would be enhanced if mastery tests were given on a regular basis. Implementation typically necessitated more time, effort, and creativity on the part of the instructor, particularly when PSI materials were not commercially available. Taveggia's concluding remarks suggested that if PSI features were incorporated into conventional courses, student mastery of content material would be enhanced accordingly. He reiterated, however, that more systematic research was necessary on PSI for a thorough evaluation.

USE OF MASTERY LEARNING CONCEPTS AND STRATEGIES

Airasian, Peter W. "An Application of a Modified Version of John Carroll's Model of School Learning." Unpublished Master's Thesis, University of Chicago, 1967.

Airasian's study applied a modified version of Carroll's Model of School Learning to produce mastery in a graduate level course in test theory with a ten-week time frame. Students were given formative evaluation tests at the end of each unit, about every two weeks. Tests were not graded, but they provided feedback to both student and teacher. For those students not attaining mastery on each unit, specific weaknesses and prescribed learning resources were suggested. Items frequently missed were corrected through instruction before moving forward. Inventories of student study-time allotments were also kept, and a graded final exam was administered to measure student performance. Results indicated that 80 per cent of the sample achieved at or above the A grades distributed the previous year on a parallel test. The author credited feedback procedures with leveling initial differences while diagnostic tests seemed to aid students by designating aims and behaviors resulting in more efficient study.

Carroll, John B. "A Model of School Learning." Teachers College Record 64 (1963): 723-33.

Carroll developed a comprehensive, yet relatively simplistic schematic design of factors which concerned student success and failure in an attempt to prevent and remediate learning difficulties. This conceptual model was intended to apply to all learning tasks that could be described in terms of achievement and with the assumption that the tasks were treated as separate and distinct. Competency included the ability to transfer previously learned knowledge to a new situation. Furthermore, many of the basic concepts of the model were measured in terms of time as a meaningful scale. In fact, the concept of time was one of the important features of Carroll's model, for the learner succeeded in a given task proportionally to the amount of time needed to learn the task. In addition, a major portion of this article presented factors which were thought to determine the length of time necessary to attain various degrees of success in learning. Also explored were determinants of time needed for learning and determinants of time spent in learning. Carroll suggested that his conceptual model could lead to further research in paced instruction, in stated parameters for differing types of learning, and in the determination of student success or failure in school learning.

Gagné, Robert M., and Leslie J. Briggs. Principles of Instructional Design. New York: Holt, Rinehart and Winston, Inc., 1974.

This book described how to systematically and practically design instruction. Topic designs, courses, and lessons in a variety of content areas were based on the principles of human learning and analysis of achievement. Part One of the book presented basic processes in learning and instruction and included topics such as instructional outcomes, learning principles, intellectual skills and strategies of learning, and attitudes and motor skills of learning. The second part of the book discussed instruction design and included the defining of performance objectives, the designing of instructional sequences, the events of instruction, the individual lesson design, and student performance assessment. The final portion of the book described instructional systems and detailed such topics as individualized instruction, designing instructional systems, and evaluation instructions. The book was intended for use in the planning and implementation of instructional programs.

Gonis, Antonios. "Arithmetic through Mastery Learning." Journal of Developmental and Remedial Education 3.2 (Winter 1979): 12-13.

Gonis explained a method used at LaGuardia College for instructing adults in arithmetic which contained many of the common features of the personalized system of instruction as well as full implementation of mastery learning principles. The author noted that while the personalized system of instruction encouraged content mastery, it did not seem to be the best possible method for mastery of higher level thinking skills. In an effort to remedy this deficiency, the alternative method used at LaGuardia allowed for maximum monitoring of student progress, utilized free time for corrective work, and allowed flexibility for the individual attempting to increase his rate. Course work was broken down into units which included formative tests and corrective procedures for those students not attaining mastery level competency. The results of the research indicated that the technique used was both viable and reliable in instructional delivery for developmental students. The results obtained were as encouraging as those obtained through a personalized system of instruction. In terms of cost effectiveness, this method was preferred to the personalized system of instruction (PSI) with a substantial reduction in cost derived from reduced tutor assistance, which was only necessary for those needing aid. Gonis included and briefly explained components of mastery learning and major characteristics of the personalized system of instruction.

Keller, Fred S. "Goodbye, Teacher. . ." Journal of Applied Behavior Analysis 1 (1968): 79-89.

Keller's paper explained a low-cost yet effective mastery approach to learning in which the teacher was responsible for facilitating the learning of all students. The study units were prepared by the students, the students were individually paced, objectives were designated, and student proctors provided reinforcement tutoring on unmastered material. Using proctors allowed retesting and immediate feedback as well as providing a personal-social interactional component. Learning units complemented laboratory work, and a teacher-prepared final exam determined student achievement. Results showed that 65-75 per cent of the students for two courses taught a year apart received A's or B's, but only a few D's and F's were issued. The article concluded by suggesting the superiority of mastery learning.

Mevarech, Zemira R. "The Effects of Cooperative Mastery Learning Strategies on Mathematics Achievement." Journal of Educational Research 78.6 (Aug. 1985): 372-77.

Mevarech's study was an overview of the initial phases of a cooperative mastery learning model. The study design investigated student teams using mastery learning strategies. This design combined cooperative teamwork as well as corrective feedback information to promote mastery of task by each individual in the group. Results showed that mathematics achievement of fifth-grade students were higher for those who were exposed to Student-Team Mastery Learning (STML) than those exposed to the material in a more conventional method. Furthermore, the research evidenced improvement in both comprehension and computation in the STML groups. Mevarech hypothesized that high-, medium-, and low-ability students would equally benefit from this method. Statistical findings and charts and graphs were included. The findings of this study encouraged further research employing the STML approach in academic achievement areas as well as on noncognitive outcomes such as the development of social skills and the internal dynamics of team learning groups.

Taylor, Susan S. "The Effects of Mastery, Adaptive Mastery, and Non-Mastery Models on the Learning of a Mathematical Task." Microfiche/ED106 145. Paper presented at the Annual Meeting of the American Educational Research Association. Washington, D.C., March 30-April 3, 1975.

Taylor's study compared adaptive mastery, typical mastery, and traditional non-mastery learning models. Each of the learning models employed differing criteria for completion of computer practice for determining student mastery or non-mastery of seventh-grade level arithmetic skills. Another major issue of the study was the examination of the efficiency of two sequencing arrangements, a clustered arrangement and a mixed arrangement. The results of Taylor's research indicated that all three models produced the same high level of performance on the posttest and a delayed retention test. However, the adaptive mastery model required less time, fewer practice items, and minimized overpractice. Moreover, the adaptive mastery approach proved most flexible in adjusting to the difficulty of the objective. No conclusions were drawn in this study regarding clustered and mixed item arrangements. Results indicated that within each objective there were differing tasks with differing rules for solving a problem. To indicate mastery, the author suggested researchers should look at the following: (1) replicating the study using differing subject matter; (2) employing the adaptive mastery model with a larger sample size to investigate the relationship between aptitude and other measures; (3) conducting a study on item arrangements; and (4) investigating the criterion for consecutive correct answers. Statistical findings were included.

Turnbaugh, Roy. "A Successful Program to Improve Student Performance." Microfiche/ED254 924. Paper presented at the Annual Meeting of the American Educational Research Association as part of "When Worlds Collide: School-University Cooperative Research," a Northwestern University Consortium. New Orleans, April 23-27, 1984.

Turnbaugh's paper reported results of a program which included basic learning skills and techniques ordered in hierarchical sequence and aimed at improved performance of all students in grades K-12. To encourage continuity and consistency, behavioral objectives in appropriately ordered sequence were monitored with criterion-referenced tests in the mathematics, reading, and language arts content areas. Rather than placing emphasis on minimum competency levels, the research stressed improving efficiency and effectiveness in a curriculum. This focus was reinforced by the sequential ordering of tasks with the most critical tasks considered the early ones in the sequence. Although successive stages were considered more varied and complex, difficulties on the early tasks needed to be corrected to avoid even more difficulties on the higher level tasks. In an effort to provide feedback on accomplishment, clarified objectives and competent measurement instruments were provided to both teachers and students. Nationally normed achievement tests were administered in a base year and in each successive year. The program was considered a success. Over a five-year period, students registered a gain of a full year in all three observed content areas. A ten-item reference list, tables, and graphs were also provided.

PROCESS AND STRUCTURE IN LEARNING AND INSTRUCTION

Task Skills Analysis

Hassett, Matthew J., and Kathleen M. McCoy. "Task Analysis: A Post-Quiz Remediation Strategy for Personalized Self-Instruction." Journal of Educational Research 73.1 (Sept.-Oct. 1979): 8-11.

The study by Hassett and McCoy analyzed the results of a post-quiz remedial strategy used in an introductory algebra course at Arizona State University. In this personalized system of instruction, mastery over units of instruction, monitored pacing, printed materials, and tutors were emphasized. This self-instruction program to improve mastery levels was a systematic alternative to the practice of curving grades in which students obtained passing grades for incomplete knowledge. Based on the principles of task analysis, the post-quiz remedial strategy included individualization of instruction as well as an analytic strategy in which all the necessary subskills required for mastery of the major task were isolated, described, and sequenced. Remediation was based on the task failed due to the lack of the subskill needed to successfully complete a specific objective.

Resnick, Lauren B., Margaret C. Wang, and Jerome Kaplan. "Task Analysis in Curriculum Design: A Hierarchically Sequenced Introductory Mathematics Curriculum." Journal of Applied Behavior Analysis 6.4 (Winter 1973): 679-710.

The aim of the research program presented in this paper was to develop a method of systematic task analysis which would specify and validate a sequence of learning hierarchies. Programs were then designed to match a child's natural sequence of acquisition which would facilitate learning in a variety of learning settings. Simply, target concepts were identified and hierarchies of specific objectives were constructed. Defining objectives identified hypothesized tasks of skilled achievement and the prerequisites necessary to learn the objectives. Sequences proposed were to maximize transfer of skills by applying a strategy in which mastery of simple tasks in a learning hierarchy facilitated the learning of more complex tasks at the higher levels of the hierarchy. Specific behavior components and their prerequisites were identified. The study concluded with a discussion of the ways in which a curriculum of mathematical skills could be implemented in schools. Also, data on children and its use was presented. The authors summarized by suggesting that laboratory and classroom studies should be undertaken to validate sequenced task analysis.

White, Richard T., and Richard E. Mayer. "Understanding Intellectual Skills." Instructional Science 9 (1980): 101-127.

This study was designed to present a framework for research on the understanding of intellectual skills. A productive learning hierarchy was the objective of instruction. Students were required to both acquire and understand the skill. Building on task analysis concepts and models of hierarchical learning, the authors attempted to establish three significant ideas. The first point stressed was that memory structure supported performance of a skill in which the elements of knowledge were seen as constituting a set of abilities which were extensions of the final skill. The second issue the article explained was a classification system the authors devised to categorize the differing types of associated knowledge which led to comprehension of skills. The third major point the authors presented was that different types of knowledge presented during skill instruction led to varying levels of understanding. White and Mayer claimed that, if steps described by them to systematize productive learning were accurate, one important effect would be to aid instructors in including important types of knowledge.

DiBiascio, Guy N. "Mastery Learning: Implication for the English Curriculum." English Education 4.2 (Winter 1973): 106-115.

DiBiascio discussed the implications that a mastery learning approach would have on the English curriculum. He suggested the application of mastery learning techniques, which included the specification of behavioral objectives, to a sequential English program. He added that the result should be the identification and logically-sequenced ordering of basic skills which would enable the student to master skills at his own rate of learning. The author went on to suggest that, within the scope and sequence of the English curriculum, mastery learning would positively reinforce the humanistic concern of self-concept for the students. DiBiascio concluded his article by stating the need for more research on sequential mastery approaches to English content.

Krathwohl, David R., John Gordon, and David A. Payne. "The Effect of Sequence of Programmed Instruction." AERJ 4.2 (March 1967): 125-132.

This study examined the effect of scrambling upon the learning of three programs dealing with basic concepts of educational measurement in an elementary educational psychology course at the sophomore college level. In each program, the judged logical interrelatedness of content was from low to very high. Achievement tests were administered to measure immediate and delayed retention. It was hypothesized that the effect of destroying sequence would be greatest for those programs having the most internal logical development within content. There was, however, no confirmation in the data for the hypothesis. Even when examining the correlation between ability and achievement under the scrambled sequence condition, there was no data to substantiate the assumption. It was also noted that the error rates in all three programs were low. Two resultant characteristics of the scrambled program were evident: (1) students recalled from memory previous items that related to the immediate task, and (2) learners were able to inductively build the knowledge as they moved through the program. The authors suggested that the study raised questions about the unexpected effects of scrambling and sequence in programmed instruction which should be further researched. Tables with detailed statistical information were included.

Levin, Gerald R., and Bruce L. Baker. "Item Scrambling in a Self-Instructional Program." Journal of Educational Psychology 54.3 (1963): 138-143.

The purpose of the experiment conducted by the authors was to validate assumptions relevant to the importance of item sequence in program presentation. By varying item sequence in a self-instructional program, Levin and Baker hoped to determine what happened to the variables of learning. A four-unit program on geometry was presented to 36 second-grade students. The control group learned items in a standard, logical sequence whereas the experimental group went through the materials in a random sequence. The resulting data indicated that performance was similar for both groups. In fact, there were no statistically significant differences on indices comparing acquisition, retention, and transfer of material learned. The authors concluded by acknowledging that no evidence was accumulated to indicate that item scrambling impaired learning. Furthermore, the data did not provide support for item sequence as an important variable in self-instructional programs. Noted was the failure of the study program to adequately teach the material to most students. It was suggested that more research should be completed on sequential structure of presentation with emphasis placed on conceptualizing the problem more adequately and operationally.

Niedermeyer, Fred, Jerry Brown, and Bob Sulzen. "Learning and Varying Sequences of Ninth-Grade Mathematics Materials." The Journal of Experimental Education 37.3 (Spring 1969): 61-6.

The experiment examined the effects of logical, scrambled, and reverse order sequences on the learning of mathematics tasks at the ninth-grade level. It was hypothesized that a logical sequence approach would be more efficient and effective, as indicated by instructional time, error rate, and posttest measures of achievement, than either a scrambled or reverse order sequence approach. Results of the study, however, did not validate the hypothesis, for findings revealed no significant differences among the sequence conditions. Moreover, there were no posttest differences between high and low ability students in the three groups. An attitude measure, however, indicated that students taking part in the logical sequence instruction considered the program interesting. The other two groups remained neutral. The authors suggested that apparently students in the scrambled and reverse order groups were able to integrate and organize the information. It was also suggested that for short programs sequence might not be as crucial to learning as previously thought. Summarizing comments concluded that perhaps, for effective learning, what was learned was more important than how it was learned.

Roe, K. Vlachouli, H. W. Case, and A. Roe. "Scrambled Versus Ordered Sequence in Autoinstructional Programs." Journal of Educational Psychology 53.2 (June 1962): 101-104.

This paper reported on an experiment designed to determine whether there was a difference in student achievement when the presentation was a proper sequential ordering of content or when the same subject items were presented in random order. Although subject matter broken into gradually progressive and logical sequential ordering has characterized teaching machine instruction, the information gathered in this study suggested that college level students may not need ordered sequence in autoinstructional programs. Students enrolled in a college course of elementary probability proceeded at their own paces through a linear program. Upon completion of the material, students were given a multiple-choice test. For one group of students, the items were in a scrambled sequence. For the other group, items were logically related and sequenced with items depending on preceding items. The sequence of items did not have a significant effect on learning time, error score during learning, test score, and time required to take the criterion test. Findings suggested, however, that ordered sequencing of items was a function of variables such as length of program, content of items, and varying learner differences. The results encouraged more research to explore scrambled versus ordered sequence questions with students of various ages and programs of differing length and subject with retention tests required at spaced intervals. Tables citing means, standard deviations, and covariance analysis were included.

Trembath, Richard J., and Richard T. White. "Mastery Achievement of Intellectual Skills." Journal of Experimental Education 47.3 (Spring 1979): 247-252.

In an investigation to see whether all members of a group of learners could attain mastery achievement by demonstrating the capacity to perform a single intellectual skill, it was shown that instruction based on a validated learning hierarchy was highly effective. Tasks were presented in a sequence consistent with hierarchical requirements and learners were required to demonstrate their achievement of each task in a logical, sequential order before proceeding to the next. Forward sequence and reverse sequence were compared with reference to learning hierarchies. With this sequential hierarchy of learning, nearly all of a group of eighth graders were able to perform the skill more efficiently than a group of eleventh graders who were able to perform the skill as part of their normal lessons. Trembath and White suggested that the results of the investigation implied that improved learning of intellectual skills could be expected if validated learning hierarchies were used to sequence learning materials as well as forcing mastery.

Learning Hierarchies

Airasian, Peter W. "Formative Evaluation Instruments: A Construction and Validation of Tests to Evaluate Learning Over Short Time Periods." Diss. U Of Chicago, 1969.

This study examined formative evaluation tests with regard to the adequacy of the teaching-learning process. One-hundred ninety students took part in the study in which facts to relatively complex thinking processes were analyzed. In addition, learning hierarchical models were translated into formative exams and items tested elements at the appropriate level in the hierarchy. Findings supported the idea that learning hierarchies could be found in certain materials and, when identified, a set of items possessing content validity could be derived to evaluate the structure and relationships inherent in the learning unit. Another result of Airasian's study indicated that students who missed items of low level content elements also missed related higher level items in the hierarchy. Generally, more than 75 per cent of the student response patterns on the formative evaluation instrument conformed to the hypothetical hierarchical model. Also discussed were uses of formative evaluation procedures in curriculum development, individualizing instruction, and mastery learning strategies.

Airasian, Peter W. "The Use of Hierarchies in the Analysis and Planning of Chemistry Instruction." Science Education 54.1 (Jan.-March 1970): 91-95.

Airasian's investigation presented results of research examining procedures developed for describing chemistry curriculum units in terms of learning hierarchies. The aim was to analyze the unit objectives as well as the relationships among objectives to produce an integrated unit which, in turn, would enable teachers to design lessons incorporating adequate aspects and supplementing inadequate aspects of provided materials. Formative evaluation methods were used to assess student performance on all objectives. From an instructional standpoint, results indicated the large majority of new content in chapters consisted of factual knowledge which was learned at recall or at a low level mental process. On the other hand, little emphasis was placed on higher level thought processes. Also noteworthy was the fact that few relationships between content elements were evidenced. In other words, elements in the chemistry books did not build sequentially, one upon another. In actuality, elements stood in isolation and did not join to produce a hierarchy leading to one high-level content element. Airasian suggested that hierarchies of related objectives would be beneficial to use when planning instruction. This hierarchical analysis could then provide a guide for producing instruction compatible to objectives.

Airasian, Peter W. "A Method for Validating Sequential Instructional Hierarchies." Educational Technology 11 (Dec. 1971):

Airasian's article proposed a method by which sequential instructional hierarchies could be validated. Specific levels, relative to the other levels, where the sequence required revision could also be identified. Airasian's approach was based on the calculation of conditional item difficulty indices in which ratios of frequencies of response patterns were tested. Included were only those response patterns in which failure on an earlier task was indicative of failure on later tasks. The conditional index of an item testing a task other than at entry level was expressed as the number of subjects who achieved the expected response pattern in which the item was correct. This number was then divided by the number of subjects who attained the expected pattern with accuracy on all previous items. Additionally, it was suggested that evidence about each item should be gathered to validate the hierarchy. The author noted that validating sequenced hierarchies consisted of demonstrating that mastery of a task indicated mastery of a task at preceding levels and that failure on any task predicted failure on all tasks. Furthermore, his method of validation indicated the location in the instructional hierarchy where the sequence required refinement. An example of the model was included.

White, Richard T. "The Validation of a Learning Hierarchy." American Educational Research Journal 11.2 (Spring 1974):

White's investigation described nine stages in validating a learning hierarchy. The results indicated that knowledge of specific individual facts was not learned in a hierarchical manner, but generalized intellectual skills were. White's research implied that instructional sequences based on a valid hierarchical structure for intellectual skills should be effective as well as useful in the assessment process. Pretests measured entry level skills, and diagnostic tests which monitored progress provided feedback. It was suggested that learning hierarchies offered close control of instruction and, therefore, afforded the opportunity to achieve mastery learning of the material relative to a specified hierarchy. Further support indicated that a complete set of prerequisite skills were essential for learning the higher skills. White added that when a set of subordinate skills was defined, the hierarchy started at the top and moved down. In the classroom setting, however, teaching started with training the enabling skills moving from bottom to top. The author encouraged a match of hierarchical subordinate elements and of hierarchical enabling skills. The following weaknesses in investigations of learning hierarchies were listed: loosely defined elements, insufficient indices, inadequate questioning of elements, improper designation of connections between elements, and forgetting elements.

Task Structure: Linking Instruction and Testing

Baker, Eva L., and Joan L. Herman. "Task Structure Design: Beyond Linkage." Journal of Educational Measurement 20 (Summer 1983): 149-63.

Baker and Herman proposed in their study that task analysis was the means by which instruction and testing could be linked since it provided a common ground for both. It was suggested that by understanding structured learning tasks that educational programs could be improved. The focal point of this design was derived from learning, instruction, and cognitive research. An analytical listing of task structure included task description, content limits, generalization and transfer, quality of discrimination and performance, linguistic features, cognitive complexity, and formatting. The authors suggested that in the future educational productivity should emphasize learning tasks which would, in turn, subordinate testing to instruction.

Birenbaum, Menucha and Doris J. Shaw. "Task Specification Chart: A Key to a Better Understanding of Test Results." Journal of Educational Measurement 22.3 (Fall 1985): 219-230.

Birenbaum and Shaw suggested the use of a task specifications chart as a tool to integrate content and procedure steps for designing and interpreting test results. The task structure or model of the skills expected of the learner emphasized what was to be learned in accordance with developmental theories of learning. An instructional unit for the addition and subtraction of fractions was used as a basis on which to demonstrate the design and application of the task specification chart (TSC). Results of two independent samples indicated that a high percentage of variance in item difficulty indices was accounted for by item characteristics that represented differing task components. Based on empirical results of the study, the authors suggested that by using a task specifications chart the instructor could design instruction that matched with task component difficulty. Moreover, it was suggested that non-mastered components could also be used to describe student achievement levels. Student errors diagnosed by classifying errors according to task components allowed for instruction evaluation and redesign. Research findings indicated that the TSC promised to be an effective tool for test design and for diagnostic assessment of student performance. Birenbaum and Shaw also added that individual student response patterns could be examined for diagnostic evaluation and prescriptive remediation for misconceptions observed. Categories indicated student errors which were analyzed by matching student response with faulty rules of operation projected from the TSC.

Haksar, Lucy. "Design and Usage of an Item Bank." Programmed Learning and Educational Technology 20.4 (Nov. 1983): 253-262.

Haksar's paper discussed the design and setting up of an item bank for low ability students in mathematics in Scottish secondary schools. Aspects of bank usage discussed included problems of translating raw scores on tests selected from the bank to measures on validated scales, test construction for a variety of purposes, and methods of recording and analyzing test results. This study concentrated on the interdependency of task specifications and design, the relationships among test interpretations, available score-measures conversions, diagnostic profiles, and the recording of both student performance and assessment of mastery. Test designs with corresponding outputs were included and suggestions for minimizing errors were also provided. A brief discussion about test efficiency concluded Haksar's report.

Linn, Robert L. "Testing and Instruction: Links and Distinctions." Journal of Educational Measurement 20.3 (Summer 1983): 179-89.

Linn looked at the relationship between testing and instruction with special emphasis on teacher-prepared classroom exams. He examined four major features of classroom tests: (1) match between test items and instructional objectives, (2) feedback, (3) indicators of important concepts, and (4) grades. The author further added that standardized tests often lack these features, thus weakening the link between testing and instruction. On the other hand, Linn advised that classroom tests were easier to match to instruction. Usually, test results offered feedback which was more specific and timely in identifying strengths and weaknesses than most standardized achievement tests. Items on teacher-developed tests indicated facts and concepts in a curriculum which were of special importance, and grades were extrinsic motivators which could not be ignored. Linn briefly highlighted the criterion-referenced testing movement which developed out of Glaser's research. Linn's summation suggested that both teacher-prepared tests and commercial standardized achievement tests were necessary to sufficiently evaluate learning.

TIME TO LEARN

Anderson, Lorin W. "An Empirical Investigation of Individual Differences in Time to Learn." Journal of Educational Psychology 68.2 (1976): 226-33.

The purpose of the study was to investigate student differences in time-on-task necessary to attain a time-to-criterion level of performance when emphasizing fixed achievement goals rather than a fixed amount of time to learn. Ninety students were involved in the experiment; the material learned was a three-unit sequence of programmed matrix arithmetic. Elapsed time, time-on-task, and achievement were three important variables. Twenty-item formative tests were administered and items tested three taxonomic levels of achievement. Conclusions of the study indicated that by initiating an effective teaching-learning strategy in an adaptive learning environment that time-on-task-to-criterion could be altered. Another conclusion drawn was that by creating environments that provided for inequalities in students that student equality could be attained both in achievement levels reached and task time needed to realize the criterion level. The summarizing argument implied that if unequal amounts of time and assistance were provided to students with inequalities in learner characteristics that over time equality in time-to-criterion might be stabilized through this leveling process.

Gagné, R. M., and N. E. Paradise. Abilities and Learning Sets in Knowledge Acquisition. Psychological Monographs, 75, No. 14 (Whole Number 518.) 1961.

This paper presented causes of individual differences in student achievement on a learning program. It tested the assumption that learning rates were determined by various kinds and amounts of knowledge. The study also examined the interrelationship between these intellectual skills, basic abilities, and achievement on a learning task. Participants were 118 seventh-graders. The learning program consisted of solving linear algebraic equations which were analyzed into a learning hierarchy. Pretests and posttests were administered, and the learning rate was measured by the number of skills achieved during successive intervals. The findings indicated that basic abilities, the most simple and general learning skills, supported the attainment of more complex skills. The basic abilities facilitated the learning of related but less complex tasks. Results implied that if less complex tasks are learned then a reduction in the amount of time required to learn more complex tasks might be achieved.

Gettinger, Maribeth. "Time Allocated and Time Spent Relative to Time Needed for Learning as Determinants of Achievement." Journal of Educational Psychology 77.1 (1985): 3-11.

This paper presented research evaluating time as a variable of learning and its effects on student achievement and retention of material presented in the classroom. Participants in the study were 171 fourth- and fifth-grade students from four midwestern public schools. Time needed for learning, time allocated for learning, and time spent in learning were systematically discussed. Findings confirmed the necessity of allocating sufficient time for learning while in school. When time was not sufficient, learning and retention decreased by 11 per cent to 18.5 per cent. Although information gained was based on short-term experimental data, implications for long-range school learning suggested that greater disparity between potential and actual achievement would occur over time if teaching time and academic engaged time did not provide time needed to learn.

Merrill, M. David. "Specific Review Versus Repeated Presentation in a Programmed Imaginary Science." Journal of Educational Psychology 61.5 (1970): 392-399.

The purpose of this study was to compare specific review with a return procedure typically used by the producers of Autotutor teaching machines in which students were required to continue to return until they selected the correct response. Additionally, comparisons were made between a single return or review presentation with the correction procedure. Forty-five college students were randomly divided into six groups to learn information about an imaginary science. Group 1 did not receive knowledge of results of criterion performance; Group 2 received right-wrong information; Group 3 repeated a previous presentation one time when incorrect performance on a criterion frame was observed; Group 4 repeated a previous presentation as many times as was needed; Group 5 received a specific review; and Group 6 received specific review until criterion frame performance was correct. Findings indicated that the most efficient procedure took place in Group 6 while Group 4 was the least efficient. In other words, specific review immediately following a presentation was more effective than waiting for a criterion question. The specific correction/review group also took less total time to complete the lessons. It should be noted that there were no observable differences in errors. The information gathered reinforced the author's suggestion that future studies based on specific review should examine time differentials of task mastery and observable error differences.

Merrill, M. David, Keith Barton, and Larry E. Wood. "Specific Review in Learning a Hierarchical Imaginary Science." Journal of Educational Psychology 61.2 (1970): 102-109.

This study examined the effectiveness of sequential mastery of a task to facilitate student learning. It was proposed that specific rather than general correction/review at each stage of the hierarchically structured learning tasks at subsequent stages would reduce errors and decrease time to learn. Also, it was suggested that students would produce greater terminal achievement, transfer, and retention of material studied. Forty college students were presented a five-lesson teaching machine course in which they were to learn an imaginary science. The experimental group was given a step-by-step specific review of misunderstood material. The control group, however, did not receive specific review when it encountered difficulties. Lessons were followed by quizzes without feedback for both groups. Criterion tests were then given, and three weeks later another test was given to measure transfer and retention. The findings were of special interest for mastery learning, for results indicated that specific review following learning difficulties increased efficiency with the total time spent on original learning by the experimental group decreasing successively across the five lessons. Furthermore, the experimental students were presented more material than the control group, yet they learned the information in less total time and with greater efficiency. Although time spent in the early stages of sequential task learning was greater than usual, less time was used in later learning. Merrill's research suggested that mastery at each successive stage in learning a task could be maintained through specific review and correction procedures without using more, and perhaps even less, instructional time than would ordinarily be used.

Resnick, Lauren B., Shirley S. Woods, and Guy J. Groen. "An Experimental Test of Five Process Models for Subtraction." Journal of Educational Psychology 67.1 (1975): 17-21.

This article described processes by which elementary school children solved subtraction problems with single digits. For analyzing reaction time, five possible models for obtaining the solution were evaluated by means of a linear regression analysis. Findings of the experiment implied that most students used a process which involved incrementing or decrementing, depending on which was the quickest procedure. It was suggested that based on the data gathered that the decrease in the slope line might indicate a developmental trend in processing speed since the fourth graders needed only about half as much time to increment or decrement as the second graders. The authors hypothesized that perhaps the older students might have moved from an essentially algorithmic procedure to a more heuristic performance. Line graphs were provided.

Sanderson, Herbert W. "Student Attitudes and Willingness to Spend Time in Unit Mastery Learning." Research in the Teaching of English 10.2 (Aug. 1976): 191-98.

Sanderson advised that a central component of mastery learning was variable time allowance, for when students were allowed as much time as was needed to learn, 80 to 90 per cent attained a level of achievement previously reached by approximately 25 per cent of the group considered. Willingness to spend time on a specific objective, rather than intelligence, was cited as the chief predictor of student success in mastery learning. The focus of Sanderson's study tested the hypothesis that student satisfaction with mastery learning and the extent of individual involvement in the instructional procedure would predict time spent in a mastery-taught English course at the tenth-grade level. Students worked with printed materials and tapes and teachers tutored when necessary. However, there was no large group instruction. Results of the study indicated that time spent significantly related to achievement. Only partial support was found to support the hypothesis. While educational acceptance and involvement in instruction significantly predicted time spent, there was a low correlation between satisfaction with mastery learning and time spent.

Seifert, Edward H., and John J. Beck, Jr. "Relationships Between Task Time and Learning Gains in Secondary Schools." Journal of Educational Research 78.1 (Sept./Oct. 1984): 5-11.

The study presented experimental data where time was evaluated as an influencing variable on student achievement and school effectiveness. Academic Learning Time (ALT), engaged time, and allocated time were defined and discussed as measures of learning. The results of the research gathered from the five Texas high schools participating in the program indicated that the discussion/lecture method of instruction where teachers were in direct control yielded the highest achievement gain. In this controlled learning environment, the students spent more time on task, listening, and thinking as the instructor challenged their intellect. The analysis of results further demonstrated that student knowledge of learning objectives encouraged their support of activities and, thereby, improved performance. The study also indicated that classroom time spent on unsupervised assignments was a waste of instructional time. Significant negative correlations were found with the use of seatwork as a learning strategy, time spent waiting for help, off-task behaviors, and total unengaged time when compared with achievement gain. Summary remarks concluded that secondary schools were susceptible to off-task influences. However, when students spent increased time-on-task, they were able to learn more. A review of related research, tables, and figures were included.

CORRECTIVES

Feedback

Johnston, James O., Norbert W. Maertens, and Daniel E. Schooley. "When to Correct Arithmetic Problems--A Critical Variable." School Science and Mathematics 69.9 (Dec. 1969): 799-805.

Research was designed by the authors to determine performance variations between knowledge of results provided after each response and knowledge of results provided after completion of the entire arithmetic exercise. The delay period of feedback given after completing each problem was shortened and intervening formal activity was eliminated. In a typical classroom situation, the interval between solving problems and knowledge of results usually involved a 24-hour delay period. The study involved three fourth-grade arithmetic classes, the same instructor, the same lessons, and identical worksheets. Seven daily assignment scores were summed and used as a single criterion measure. Results supported the position that improved performance was achieved when the delay period was free of formal activity. Findings indicated that those students receiving immediate knowledge of results performed significantly higher than those who did not. Additionally, the authors suggested that teachers should develop techniques which would provide immediate per problem knowledge of results after each problem to increase student achievement. It was suggested that further research should be undertaken to substantiate the results of this study.

McMeen, George R., and Joseph H. Thorman. "Immediate Results in Objective Testing." Clearing House 55.3 (Nov. 1981): 140-41.

McMeen and Thorman cited the importance of providing students with immediate knowledge of results about the accuracy of their responses on multiple-choice tests for improved performance. The authors suggested that using computers as tutors and computerized card scoring were promising methods of providing immediate feedback, but availability of computer terminals, delay time for processing cards, and costs were listed as disadvantages. However, information was given on four alternative electronic or mechanical devices for rapid test scoring. Advantages and disadvantages of each were also discussed. Summary comments indicated that there were devices available, other than computers, to help simplify and improve test administration for the classroom teacher in his/her effort to encourage student learning.

Mevarech, Zemira Rivka. "The Role of Teaching-Learning Strategies and Feedback-Corrective Procedures in Developing Higher Cognitive Achievement." Diss. U of Chicago, 1980.

Mevarech's experimental study focused on the effects of feedback-diagnostic/prescriptive procedures and problem-solving strategies for critical thinking skills relative to mathematics. Examined also were entry behaviors in the cognitive domain and performance with varying instructional procedures. In addition, relationships between behaviors in high mental process and low mental process were investigated within differing learning environments. A specific-algorithmic strategy without feedback-correctives, a general heuristic approach without feedback correctives, a specific algorithmic strategy with feedback-correctives, and a general-heuristic strategy followed by cognitive feedback-correctives were the four settings used to examine learning opportunities. Findings indicated that a majority of the students were able to attain mastery on both high and low level thinking skills only when both problem-solving instructional strategies and feedback-corrective procedures were stressed. In this learning setting, previous achievement accounted for less than 5 per cent of the variation in scores whereas previous achievement in a conventional situation accounted for much of the variation in higher mental process (hmp) achievement. Mevarech encouraged further research in developing cognitive competence in the higher level critical thinking skills.

Tutoring

Grossman, Anne S. "Mastery Learning and Peer Tutoring in a Special Program." Mathematics Teacher 78.1 (Jan. 1985): 24-27.

A City University of New York and Board of Education Consortium was formed to improve high school students' skills which would enable them to succeed at the college level. Fifty marginal sophomores of a New York City high school were participants in the experiment. This program in mathematics instruction provided a double-period class in algebra which eliminated the need for a remedial teacher and allowed time for carefully developing math concepts. In addition to the double-period class, teaching methods were changed to a combination of mastery learning techniques and peer tutoring. Peer tutors provided reteaching on a correction day for those students who did not achieve mastery (85 per cent) on an initial test in a teaching, testing, correcting, and retesting procedure. Correcting errors on formative tests was the focus of peer tutoring sessions. The experiment was considered a success. The instructor had more time available to teach, students learned from each other, student performance improved, and regular attendance replaced unjustified absenteeism.

Error Analysis

Anderson, Lorin W. and Others. "Using Errors to Improve the Quality of Instructional Programs." Microfiche/ED 169 101. Revision of a paper presented at the Annual Meeting of the American Educational Research Association. Toronto, Ontario, Canada, March 27-31, 1978.

The study reported on results of a program designed to focus on the analysis of student errors as an aid to improve instructional programs. Anderson added that while the number of correct items measured actual performance it did not offer ways to improve instruction. Because errors indicated misunderstandings, he suggested that the types of errors might lead to alterations in instruction which, in turn, would lead to improved student performance. The mathematics programs in two elementary schools were used in the study, grades 1-6. One school used a mastery learning approach while the other used a program believed to be representative of traditional instructional programs. Program effectiveness was defined in terms of retention, with tests designed to measure understanding of concepts, the ability to compute accurately, and the accurate use of algorithmic operations. Errors were classified as computation, omission, and algorithmic. By using an error analysis approach, remedial efforts were designed to correct a specific type error. Systematic approaches and suggestions for differing errors were included. Anderson summarized by suggesting that typing and diagnosing errors could be used both to evaluate and improve instructional programs.

Response Patterns: Erroneous Use of Rules of Operation/Algorithms

Birenbaum, Menucha and Kikumi K. Tatsuoka. "On the Dimensionality of Achievement Test Data." Journal of Educational Measurement 19 (Winter 1982): 259-66.

Birenbaum and Tatsuoka compared results of pre- and post-tests designed to measure achievement when using an algorithmic approach. Simulated data was used to analyze response patterns to addition problems with signed numbers. Findings indicated that notable variances in test scores or identical scores occurred when application of differing yet incorrect algorithms were consistently applied. The authors added that it followed that total test score validity was questionable in view of results based on the number of correct answers, for the use of wrong algorithms did yield correct answers in some instances. Arguments were presented suggesting that the use of response patterns requiring algorithms was preferable to right/wrong response totals.

Birenbaum, Menucha and Kikumi K. Tatsuoka. "The Effect of a Scoring System Based on the Algorithm Underlying the Students' Response Patterns on the Demensionality of Achievement Test Data of the Problem Solving Type." Journal of Educational Measurement 20.1 (Spring 1983): 17-25.

The purpose of the Birenbaum and Tatsuoka paper was to illustrate the variances in information obtained through test scores when basing conclusions solely on the number of accurate responses in evaluating achievement of problem-solving skills. The authors advised that because achievement tests were designed to measure the outcome of instruction, the aim of teaching was to provide the student with the correct rule of operation. This study indicated, however, that when solving problems students tended to modify algorithms taught in class, and often the modifications were erroneous. Furthermore, when applying these inaccurate algorithms, the students were often able to produce the right answer. The authors provided an example of a subtraction problem worked by a student who consistently borrowed a ten as in whole numbers. Research findings suggested that adaptive tests should aim at correcting student misconceptions to enable the student to have a better understanding of the problem-solving strategy. Also explained by the authors were data collection procedures, scoring systems, reliability and dimensionality of research results. Additionally, tables which provided means, standard deviations, correlations, and variation of test results were included.

Brown, John Seely and Richard R. Burton. "Diagnostic Models for Procedural Bugs in Basic Mathematical Skills." Cognitive Science 2 (1978): 155-192.

This paper consisted of four sections which discussed diagnostic problems of failures in procedural skills and a new diagnostic modeling system for synthesizing a deep-structure model of misconceptions to provide a means for identifying and explaining why a mistake was made. The system presented was successfully used to diagnose 1300 students with a data base of 20,000 test items. The general framework of the research was based on a procedural network to represent knowledge in a structured breakdown of skills into subskills. It was noted that diagnosing misconceptions was quite subtle, for while students were capable procedure followers, they often followed the wrong procedure which resulted in the inability to perform each task correctly. The structure of the network allowed for efficient modification of bugs in a student's encoding system as well as explanatory information used for remediation. A computer-based tutoring/gaming program was used in the teaching of how to diagnose misconceptions. Uses of a network for automatically diagnosing student behavior was included. Also discussed was the success of the system.

Brown, John Seely and Kurt VanLehn. "Repair Theory: A Generative Theory of Bugs in Procedural Skills." Cognitive Science 4 (1980): 379-426.

This study presented a generative theory of bugs in procedural skills which predicted systematic misconceptions of students while in the process of learning a skill. This theory was also capable of offering explanations of why specific bugs were found, of how bugs were caused, and of predictions of bugs for procedural skills not yet analyzed. Additionally, the Repair Theory described was a process which generated bugs by formal deletion operations. These operations modeled incomplete learning and forgetting by using a constrained rule deletion procedure as well as a problem solver which made repairs. To retain predictive capability, constraints were placed on this theory to limit its applicability to any data. Also included were procedures generated by Repair Theory, descriptions of procedural errors, and a detailed explication of this generative theory. Future research suggestions consisted of application of the theory to domains other than subtraction, the content which was used in this study, and the development of a learning theory for procedures which would account for errors that the Repair Theory could not.

Harnisch, Delwyn L. "Item Response Patterns: Applications for Educational Practice." Journal of Educational Measurement 20.2 (Summer 1983): 191-206.

The focus of Harnisch's manuscript was on recent psychometric techniques used to identify atypical response patterns and their diagnostic value. Harnisch commented that multiple-choice items contributed to discrimination of distractors similar to the correct answer, but they did not tell the student what he was doing incorrectly. The author went on to imply that total test scores were not useful in analyzing errors. Further discussion elaborated about the possibility of supplementing instruction through analysis of item response patterns and supported systematic construction of distractors for item sets. This would then provide information about student errors. The study further examined indices of response patterns, practical applications, and limitations and advantages. An extensive bibliography was included.

Tatsuoka, Kikumi, K., and Maurice M. Tatsuoka. "Spotting Erroneous Rules of Operation by the Individual Consistency Index." Journal of Educational Measurement 20.3 (Fall 1983): 221-30.

Motivated by the belief that simple right and wrong answers provided response patterns derived through erroneous algorithms, Tatsuoka and Tatsuoka presented a technique which detected atypical response patterns that uniquely corresponded to erroneous algorithms. An individual consistency index (ICI) proposed by the authors measured changes in response patterns of individuals and depended on the difficulty of the task with items arranged in order of increasing difficulty. Although ICI measured the stability of a student's algorithm, it also was of assistance in detecting systematic misconceptions throughout tests in any domain. ICI was useful for assessing student understanding when tests were designed to determine progress and were an essential component of instruction. Moreover, ICI was an alternative to expensive error analysis systems.

Webb, Noreen and Joan Herman. "Diagnosing Students' Errors from Their Response Selections in Language Arts." Microfiche/ED252 556. Report by the Center for the Study of Evaluation, University of California. Los Angeles: November, 1984.

This paper described a project developed to diagnose student errors in language arts. A computerized adaptive testing program was used to assess the consistency of student response patterns in an attempt to discover erroneous rules of usage and student misconceptions. A domain-referenced test on pronoun usage was given to sixth graders, individually and as groups, who were also asked to explain their responses. To diagnose erroneous rules, it was assumed that a misconception could only lead to a wrong answer and that a response error would lead to the same incorrect answer for matched items. Results indicated that student errors were inconsistent and that while responses were not random, conceptualization of the problem seemed to vary. The findings did not encourage use of this approach in the classroom in content areas other than mathematics. Webb and Herman implied that their study might raise important questions about cognitive models which support systematic and analytic approaches to the taking of tests.

EDUCATIONAL TECHNOLOGY

Designs and Strategies for Computer-Assisted Instruction/ Computer-Managed Instruction Systems

Chitayat, Linda. "An Evaluation of Computer-Managed Education Technology at New York City Community College." Microfiche/ED144 524. Case-32-76 by City University of New York, New York Institute for Research and Development in Occupational Education. Brooklyn: New York City Community College, May 1976.

The Computer-Managed Education Technology Program (COMET) was designed to provide more effective group instruction through the use of electronic resources. Specifically, the study was intended (1) to improve feedback of student comprehension during the instructional period, (2) to facilitate homework and quiz procedures, (3) to use multimedia equipment, and (4) to provide effective methods of independent study for remedial purposes. For evaluation purposes, most professors found the components of the computer management program to be useful tools, especially for drill and practice in introductory courses that required mastery of a great deal of basic information. An extensive listing of both positive and negative comments were provided. Results of the study indicated that computerized education could be valuable for instructional purposes, but more research was needed as well as greater refinement in computer capabilities for classroom use.

Jeffcoat, Colin. "CPS: A Self-Assessment Scheme." Assessment in Higher Education 4.3 (June 1979): 180-186.

The purpose of the Course Progress Survey (CPS) was to outline a self-assessment scheme in which students monitored their progress by taking a series of informal multiple choice tests. Answer cards were marked and report sheets listing correct answers and remedial advice for incorrect responses were provided through the use of a computer program. This program was optional so its use was, therefore, on an informal basis. In general, above average ability and average ability students opted to use the program. For participating students the survey was popular. A main feature of the program was the use of report sheets as part of a diagnostic-corrective feedback measure. Operation of the Course Progress Survey was simple, not requiring specialized computer knowledge. The author indicated that this program had been used for five years in first-year mathematics and statistics classes offered by Victoria University in New Guinea. Jeffcoat suggested that such a program could be easily adapted for other course content.

Resta, Paul F., Joel E. Strandberg, and Edwin Hirsch. "Strategies for Development of Computer-Based Instructional Management Systems." Microfiche/ED046 255. Southwest Regional Educational Laboratory, Inglewood, California. Paper presented at the Annual Meeting of the American Educational Research Association. New York, 1971.

The purpose of this paper was to distinguish the differences and similarities between instructional management systems and instructional monitoring systems. The authors accomplished this by analyzing components of both systems, by identifying appropriate computer support, and by discussing tasks necessary for developing better quality monitoring and management systems. Their analysis revealed that most instructional management systems were limited to test scoring and reporting functions and might best be considered instructional monitoring systems. The authors included a flowchart and a detailed discussion of a generalized computer-assisted monitoring and management system in which both negative and positive aspects were pointed out. Summary remarks suggested that specific components of computer support needed to be identified, that cost effectiveness must be realized, and that applicable hardware/software materials must be available. The authors emphasized that the development and validation of instructional decision rules was critical to the establishment of such systems.

Stolurow, Lawrence. "Some Factors in the Design of Systems for Computer-Assisted Instruction." Microfiche/ED033 600. Technical Report No. 7, Office of Naval Research, Contract No. N00014-67-A-0298-0003, Harvard University. Cambridge: Harvard Computing Center, 1968.

Stolurow's report presented a theoretical analysis of adaptive instruction by using computer assistance to individualize learning. Flexible logic, memory capabilities of computers, and an instructional program handling such variables as who was being taught, what was critical, and how the teaching was to be done were discussed. Additionally, the program also needed to designate whether instruction should be drill and practice, problem solving, inquiry, simulation and gaming, or tutorial. An idiographic model was described as an adaptive instructional approach which included prescriptive aspects of programmed instruction. Summary information was provided on a study which used computer-assisted instruction language and symbolic logic for achieving individualization and student participation. An extensive bibliography was included.

Support Systems for Mastery Learning
Components and Strategies

Airasian, Peter W. "The Use of Machines in Formative Evaluation." AEDS Journal 5.4 (June 1972): 117-124.

According to Airasian, machines served a multitude of necessary roles in the formative evaluation process. Because formative evaluation was an on-going procedure, the author advised that the principal value of machines was the speed with which they provided desired data to make appropriate information available at a crucial time. Rather than terminal evaluation over a lengthy period of instruction, the learner was informed of non-mastery at a time when he could correct his errors. This information was especially relevant in early stages of instruction since it was a necessary prerequisite for learning related objectives. Airasian suggested constructing items based on logical sequence of presentation with a hierarchy of dependent objectives which not only identified specific errors but also showed how errors and objectives related within the learning hierarchy. Machines played the major role in the formative evaluation process after hierarchies and instruments were constructed. The use of machines in formative evaluation, therefore, provided a reciprocal relationship between educational objectives, learning experiences, and education.

Calhoun, W. Ford and Robert B. Frary. "Computer-Supported Individualized Testing Within Reach." Educational Technology 18.1 (Jan. 1978): 45-8.

After presenting a listing with brief explanations of deficiencies in typical testing situations, the authors built a case for individualized testing. The article went on to report the development, implementation, and evaluation of a computer-supported individualized testing system that featured a special item file design, a method for creating different yet equivalent exams, a provision for published item files, and a testing area separate from the classroom. The procedure followed in a trial implementation of the system allowed college level students to take tests at their convenience, thereby, allowing for varying rates of learning. The student was allowed to take tests twice, but the retake negated the first test score. There were no time limits. After a two-week testing period, evaluations by students were positive with a large majority believing they had learned more as a result of retaking the tests. In addition to the educational and efficiency benefits, the findings suggested that implementation of such a system could lead to a variety of applications.

Shale, Douglas and Donald Cowper. "A Computer-Based Support System for Mastery Instruction." Assessment and Evaluain Higher Education 7.2 (Summer 1982): 167-180.

The system described in this article supported mastery learning through computer-managed instruction and was designed to alleviate, to a large degree, the practical problems of an instructional program that adhered to the basic principles of the model. Although this system did not have the capabilities of a stringent CMI system, it was a relatively simple and inexpensive way to support mastery instruction. Basic components of the system included optically-scanned answer cards which were computer scored and the scores for prescribed subsets of test questions were used for diagnostic and prescriptive purposes for remedial instruction. Furthermore, continuous feedback guided students, individually, through various stages of the instructional process. Data used to evaluate this system was based on costs, reliability, and effects on the instructional process. Also included were details of the system design and hardware and software information. The authors concluded their study by recommending this system for the traditional classroom setting.

Testing/Scoring Systems

Anderson, David E. "Microcomputer Card Reader System for Test Scoring and Item Analysis." Microfiche/ED223 654. Reports - Descriptive (141). 1982.

This article described a computer system for test scoring which was made up of an optical mark sense card reader interfaced with a microcomputer. The author related his experiences when using the program for over nine months. During the study, this system enabled the instructor to easily do extensive diagnostic testing with item analysis. Furthermore, the amount of time required in selecting test items for students of varying abilities was greatly reduced. The total cost of the system was below $5,000, which was a less expensive alternative to the price of a test-scoring machine. Available software, hardware, and answer card design were explained.

Miller, Marvin M. "The Computer and Testing." NASSP Bulletin. Feb. 1970: 41-47.

Miller's article elaborated on the varied used of computer systems in testing situations. His basic premise was that computers should be used to do impersonal tasks more efficiently than teachers could do them. This, in turn, would allow teachers more time to complete their main duties. Miller added that computers were capable of preparing test-related activities more accurately than teachers. Additionally, machine scoring and computer analysis of objective classroom tests opened up many diagnostic possibilities, for item analysis indicated difficult and misunderstood test items. It was also suggested that a computer system may be used as a practical method of gathering data of many types for better teaching and better learning. Miller concluded his paper by cautioning against the compilation of reports involving an overabundance of information not needed by the instructor.

Powell, George D. "The Use of Mark-Sense Readers in Evaluation." Microfiche/ED247 269. Paper presented at the Annual Meeting of the American Educational Research Association. New Orleans, April 1984.

In his paper, Powell discussed the usefulness of mark-sense readers in locally produced evaluations. Mark-sense readers were defined as a class of electronic devices that either electrically or optically sensed marks placed on paper and changed them to electronic information. The author stated that the most common use of mark-sense recorders was for scoring tests. Two advantages of using these electronic devices for test scoring were the quick turnaround time and the low cost per student tested. Even the most complex criterion-referenced tests could be scored by the mark-sense reader if appropriate microcomputer hardware and software were used. Many widely-used diagnostic, placement, and normative tests could be scored by this method. The main disadvantage of using mark-sense readers was the limit on answer sheet formats, for most affordable readers use cards or half-page sheets for recording data. In the past 20 years, mark-sense readers have been used on a large scale for test scoring in education. With smaller, less sophisticated, and less expensive mark-sense readers available in the past 10 years, the use of the readers for evaluation became both affordable and practical. Other evaluation-oriented tasks that were discussed included (1) data collection from surveys and polls, (2) evaluations of training sessions and courses, and (3) data entries of descriptive and demographic information on students.

SUMMARY

To provide an overview of research results described in the bibliography, the following summaries have been prepared.

I. Summary of Related Research: Although approaches to mastery learning varied, they did share many of their major features. Learning for mastery was defined in clearly stated objectives that students were to achieve. Units taught consisted of materials arranged logically and systematically to produce intended learning, and students were required to reach mastery levels on each unit before proceeding to the next. Diagnostic-progress tests were administered when the unit was completed to provide feedback and to measure performance. Materials with appropriate correctives supplemented original instruction to encourage mastery. Bloom's modifications of mastery learning represented a great advance over previous strategies, for refinements in feedback instruments enabled more effective teaching and better student performance (Bloom, 43-56). Then, Gagné's learning hierarchy model and its emphasis on interrelationships and structures in terms of constituent elements further advanced improved diagnostic instruments (Gagné, Principles, 35-52). In the area of formative evaluation, Airasian's research led to implementation of continuous feedback devices for student and teacher in an on-going modification process of instruction and learning to enable the learner to attain mastery (Airasian, "Formative Evaluation"). More recently, a greater variety of

instructional correctives were employed. Correctives functioned to provide instructional cues, practice, and the amount and type of reinforcement needed to successfully complete the learning task. Small-group study sessions, peer tutoring, alternate instructional materials, and re-teaching were some of the methods used. For diagnosing student misconceptions, error analysis studies (Anderson, L., "Using Errors," 2) and assessments of learner response patterns have been tested (Webb, 1). To further improve the quality of instructional progress, task analysis research programs have continued efforts to validate learning hierarchies to assist in the development of instructional materials designed to guide the student through a logical sequence of acquisition (Resnick, Wang, and Kaplan, 679). Researchers have also examined time as a variable of learning with indications that when more time was spent on task the greater the amount of learning (Seifert and Beck, 9). Even more progressive feedback/ corrective procedures have been examined and on-going research has taken place to improve group instruction through the use of technological aids in the classroom. The use of educational technology, specifically computers, in the classroom was a significant development as a support system for mastery learning which provided a relatively sophisticated level of diagnostic and remedial procedures (Stolurow, 1; Shale and Cowper, 167).

II. Use of Mastery Learning Concepts and Strategies:

Mastery strategies were designed to promote each student's

optimal cognitive and affective development. Generally, the approaches took into account individual differences among learners, and educational objectives students were expected to achieve were clearly defined. The task was usually accomplished by adjusting the learning time and/or the quality of instruction through various corrective measures. The results from the studies researched indicated that mastery learning approaches had considerable effect on student cognitive and affective development as well as their learning rate (Taylor, 1-43). Typically, students were able to achieve high levels, reaching performance standards that usually only the top fourth of the learners were able to attain when learning in a traditional classroom setting where instructional approaches were group based. Mastery learning strategies seemed to be most effective for students with learning problems and/or low-level achievement under conventional conditions. For example, students with below average I.Q. scores seemed to learn as well as those students with average ability and above average I.Q. scores. The academically-abled students continued to perform at high levels and, rather than repeating previously mastered materials, were encouraged to work on enriched activities (Sanderson, 192). Mastery procedures also appeared to induce a leveling effect, for when students had achieved prerequisite knowledge the effects of individual learning differences were almost all eliminated. Often, student attitude toward the material was more positive and student self-concept was improved. Most students

who had learning problems overcame feelings of passivism and defeatism. These affective consequences were attributed to the encouragement provided through positive reinforcement and to the provision of an environment which gave students the opportunity to succeed. Furthermore, the atmosphere for learning was cooperative rather than competitive, and the use of certain correctives such as peer tutoring added a personal-social aspect to learning that was not always available in a traditional group-based setting. Overall, student learning became increasingly efficient. Moreover, instructional time spent in mastering the earliest units in the subject seemed to result in the need to spend less time than usual in learning material presented later in the units (Mevarech, "The Effects of Cooperative," 375; Taylor, 21-37).

III. Process and Structure in Learning and Instruction: Gagné's model of learning hierarchies has proven useful when describing what someone must know in order to learn, for the learning hierarchy specified skills which needed to be learned before a higher skill could be learned (Gagné and Paradise). Furthermore, studies based on validated learning hierarchies indicated that it was effective to sequence tasks and to require learners to master each task in turn before proceeding to the next (Trembath and White, 247). In another paper, White described the validation of hierarchies and results supported Gagné's suggestion that intellectual skills were learned hierarchically while verbal skills were not. On the other hand, an experiment conducted

by Niedermeyer, Brown, and Sulzen ("Learning and Varying Sequences," 61) was unable to validate the sequence hypothesis, for when comparing logical, scrambled, and reverse frame orders, there were no significant differences. In another report (Roe, Case, Rose, 101), the sequence of items again had no effect on learning time, error score, and criterion test score. However, the point was made by Baker and Herman ("Task Structure Design," 149) that linking tests and instruction could best be accomplished through the comprehension of learning tasks. For more effective learning, procedural steps of a specified task could also be integrated with content through the use of task specification charts (Birenbaum and Shaw, 219).

IV. Time To Learn: Students varied in the amount of time required to learn for mastery whether enrolled in a traditional instructional program with fixed time allotments to learn or in a more innovative mastery instructional program with time variations for learning and fixed performance goals (Anderson, L., "Empirical Investigation," 226). Furthermore, according to Cronbach in Aptitudes and Instructional Measures, a student's learning rate could be predicted by his aptitude. Increasingly, instructional strategies have been designed to enhance each learner's rate and accomplishments by allowing the learner the necessary time needed to learn and master the material. Although slow learners with low-level ability have taken up to four times as long to master a task as high-ability students, the students with

learning difficulties were able to learn and to increase achievement when they were given the opportunity--sufficient time--to learn (Anderson, L., "Empirical Investigation," 227). Specific review work completed by Merrill resulted in increased efficiency with students requiring less time for mastery on successive lessons in a unit. While more time than usual was required to ensure mastery of early units, the total time was no more, and perhaps less, than that used with conventional methods (Merrill, Barton, and Wood, 105-108).

V. Correctives: Knowledge of results has been shown to be a factor in ability, in achievement, and in motivation and has become one of the ends of the educational process (McMeen and Thorman, 140-141). Formative diagnostic procedures built into instruction to point out misconceptions in learning an instructional segment and which suggested corrective strategies to overcome errors has been a promising supplementary approach to usual group-based instruction (Airasian, "The Use of Machines," 117). Correctives have included cooperative team study approaches (Mevarech, "The Effects of Cooperative," 372-373), individualized tutoring (Grossman, 25), computer-assisted instruction, computer-managed instruction (Stolurow; Resta), re-teaching selected aspects of instruction, and the availability of alternative instructional materials and methods. Evidence has suggested that tutoring has been the most effective feedback/corrective procedure (Hartley, iii). Additionally, peer tutoring has resulted in improved rapport among students and between the teacher and students (Grossman, 27).

Recent studies have been implemented to classify errors (Anderson, L., "Using Errors") and response patterns to diagnose misunderstandings. Birenbaum and Tatsuoka ("On the Dimensionality," 61) suggested using information from both right and wrong answers to identify the thinking process used when completing response patterns, for often learners were able to produce correct answers although the wrong algorithms were initiated. In their corrective research, Brown and Burton have described a procedural network as a means of representing a diagnostic model for identifying learner failures in procedural skills. However, capabilities of this system have been diagnostic and no tutoring has been attempted ("Diagnostic Models"). Tatsuoka and Tatsuoka reiterated the importance of diagnosing learner misconceptions and developed a general technique, the Individual Consistency Index, to detect atypical responses and to provide the learner with the correct rule of operation, taking into consideration the underlying process ("Spotting Erroneous"). Contrary to recommendations produced in other studies, Webb and Herman ("Diagnosing," 16) indicated that student answers to a language arts test were inconsistent and did not warrant analyzing student response patterns for the classroom. Most studies indicated that feedback devices and instructional correctives were key variables of learning and of promoting successful school experiences.

VI. Educational Technology: Technological aids have had considerable effect on the field of education and the

uses of computers to assist, to manage, and to monitor instruction have been vast. Computer systems have provided services ranging from preparation of materials to solving highly complicated numerical problems (Stolurow; Resta; Miller, 41). Computer programs designed for group instruction have provided improved and immediate feedback to both students and teachers and have supplemented traditional instruction with tutorial services and guidance (Chitayat). According to Airasian ("The Use of Machines," 123), the most significant feature of the computer in a formative evaluation process has been the ability of the machine to provide information quickly and when it has been most useful--during instruction. Machines could serve a number of vital functions to improve instructional and evaluative procedures with speed and accuracy. However, more simple and more affordable programs should be developed so that their use could be cost effective for classroom use (Calhoun and Frary, 46).

CONCLUSIONS

Mastery learning strategies have offered exciting possibilities in the field of education. Ideas presented could provide teachers with knowledge of effective ways to provide instruction of optimal quality for each learner. Although the instructor must expend time and energy in mastery learning preparation, the results could be improved achievement for most students. Administrators should be encouraged to locate mastery strategies that could be easily and affordably adapted to present instruction methods. Through the use of mastery approaches, students could be provided with necessary skills to encourage high school completion and the higher education our society increasingly demands. Furthermore, school success experiences would be encouraged which would help build the self-confidence necessary to achieve. Finally, mastery learning has promised numerous opportunities for curriculum-planners and researchers to explore in an effort to improve the teaching-learning process.

RECOMMENDATIONS

Several promising areas for further research in mastery learning can be suggested as follows:

1) the development of more effective feedback/correct procedures
2) the development of mastery learning curricula
3) the development of affordable technological systems designed for group-based classroom instruction
4) the development of more detailed studies on the relationship between learning and sequentially ordered instruction
5) the development of more detailed studies relating error analysis and improved learning
6) the development of a mastery strategy which would teach the learner how to think

BIBLIOGRAPHY

A Nation At Risk: The Imperative for Educational Reform. A Report to the Nation and the Secretary of Education, United States Department of Education by The National Commission on Excellence in Education. April 1983. (4)

A Nation Prepared: Teacher's for the 21st Century. Carnegie Task Force on Teaching as a Profession. Carnegie Forum on Education and the Economy, 1986. (4)

Airasian, Peter W. "An Application of a Modified Version of John Carroll's Model of School Learning." Unpublished Master's Thesis, U of Chicago, 1967. (17)

---. "A Method for Validating Sequential Instructional Hierarchies." Educational Technology 11 (Dec. 1971): 54-56. (27)

---. "Formative Evaluation Instruments: A Construction and Validation of Tests to Evaluate Learning Over Short Time Periods." Diss. U of Chicago, 1969. (26)

---. "The Use of Hierarchies in the Analysis and Planning of Chemistry Instruction." Science Education 54.1 (Jan.-March 1970): 91-95. (26)

---. "The Use of Machines in Formative Evaluation." AEDS Journal 5.4 (June 1972): 117-124. (42)

Anderson, David E. "Microcomputer Card Reader System for Test Scoring and Item Analysis." Microfiche/ED 223 654. Reports - Descriptive (141). 1982. (43)

Anderson, Lorin W., and Others. "Using Errors to Improve the Quality of Instructional Programs." Microfiche/ ED 169 101. Revision of a paper presented at the Annual Meeting of the American Educational Research Association. Toronto, Ontario, Canada, March 27-31, 1978. (36)

---. "An Empirical Investigation of Individual Differences in Time to Learn." Journal of Educational Psychology 68.2 (1976): 226-33. (30)

Baker, Eva L., and Joan L. Herman. "Task Structure Design: Beyond Linkage." Journal of Educational Measurement 20 (Summer 1983): 149-63. (28)

---, and Doris J. Shaw. "Task Specification Chart: A Key to a Better Understanding of Test Results." Journal of Educational Measurement 22.3 (Fall 1985): 219-230. (28)

---, and Kikumi K. Tatsuoka. "On the Dimensionality of Achievement Test Data." Journal of Educational Measurement 19 (Winter 1982): 259-66. (36)

---, and Kikumi K. Tatsuoka. "The Effect of a Scoring System Based on the Algorithm Underlying the Students' Response Patterns on the Dimensionality of Achievement Test Data of the Problem Solving Type." Journal of Educational Measurement 20.1 (Spring 1983): 17-25. (37)

Block, James H., ed. Mastery Learning: Theory and Practice. New York: Holt, Rinehart and Winston, Inc., 1971. (14)

Bloom, Benjamin S., J. Thomas Hastings, and George F. Madaus. Handbook on Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill Book Company, Inc., 1971. (14)

Brown, John Seely and Richard R. Burton. "Diagnostic Models for Procedural Bugs in Basic Mathematical Skills." Cognitive Science 2 (1978): 155-192. (37)

---, and Kurt VanLehn. "Repair Theory: A Generative Theory of Bugs in Procedural Skills." Cognitive Science 4 (1980). 379-426. (38)

Calhoun, W. Ford and Robert B. Frary. "Computer-Supported Individualized Testing Within Reach." Educational Technology 18.1 (Jan. 1978): 45-8. (12)

Carroll, John B. "A Model of School Learning." Teachers College Record 64 (1963): 723-33. (18)

Chitayat, Linda. "An Evaluation of Computer-Managed Education Technology at New York City Community College. Case 32-76 by City University of New York, New York Institute for Research and Development in Occupational Education. Brooklyn: New York City Community College, May 1976. Microfiche/ED 144 524. (40)

Cronbach, Lee J., and Richard E. Snow. Aptitudes and Instructional Measures. New York: Irvington Publishers, Inc., 1977. (14)

DiBiascio, Guy N. "Mastery Learning: Implications for the English Curriculum." English Education 4.2 (Winter 1973): 106-115. (23)

Gagné, Robert M., and Leslie J. Briggs. Principles of Instructional Design. New York: Holt, Rinehart and Winston, Inc., 1974. (18)

---, and N. E. Paradise. Abilities and Learning Sets in Knowledge Acquisition. Psychological Monographs, 75, No. 14 (Whole Number 518.) 1961. (30)

Gettinger, Maribeth. "Time Allocated and Time Spent Relative to Time Needed for Learning as Determinants of Achievement." Journal of Educational Psychology 77.1 (1985): 3-11. (31)

Glaser, Robert. "The Future of Testing." American Psychologist 36.9 (Sept. 1981): 923-36. (15)

Gonis, Antonios. "Arithmetic through Mastery Learning." Journal of Developmental and Remedial Education 3.2 (Winter 1979): 12-13. (19)

Grossman, Anne S. "Mastery Learning and Peer Tutoring in a Special Program." Mathematics Teacher 78.1 (Jan. 1985): 24-27. (35)

Haksar, Lucy. "Design and Usage of an Item Bank." Programmed Learning and Educational Technology 20.4 (Nov. 1983): 253-262/ (29)

Harnisch, Delwyn L. "Item Response Patterns: Applications for Educational Practice." Journal of Educational Measurement 20.2 (Summer 1983): 191-206. (38)

Hartley, Susan Strait. "Meta-Analysis of the Effects of Individually Paced Instruction in Mathematics." Diss. U. of Colorado, 1977. (15)

Hassett, Matthew J., and Kathleen M. McCoy. "Task Analysis: A Post-Quiz Remediation Strategy for Personalized Self-Instruction." Journal of Educational Research 73.1 (Sept.-Oct. 1979): 8-11. (21)

Jeffcoat, Colin. "CPS: A Self-Assessment Scheme." Assessment in Higher Education 4.3 (June 1979): 180-186. (40)

Johnston, James O., Norbert W. Maertens, and Daniel E. Schooley. "When to Correct Arithmetic Problems--A Critical Variablle." School Science and Mathematics 69.9 (Dec. 1969): 799-805. (34)

Keller, Fred S. "Goodbye, Teacher. . ." Journal of Applied Behavior Analysis 1 (1968): 79-89. (19)

Krathwohl, David R., John Gordon, and David A. Payne. "The Effect of Sequence of Programmed Instruction." AERJ 4.2 (March 1967): 125-132. (23)

Levin, Gerald R., and Bruce L. Baker. "Item Scrambling in a Self-Instructional Program." Journal of Educational Psychology 54.3 (1963): 138-143. (24)

Linn, Robert L. "Testing and Instruction: Links and Distinctions." Journal of Educational Measurement 20.3 (Summer 1983): 179-89. (29)

McMeen, George R., and Joseph H. Thorman. "Immediate Results in Objective Testing." Clearing House 55.3 (Nov. 1981): 140-41. (34)

Merrill, M. David, Keith Barton, and Larry E. Wood. "Specific Review in Learning a Hierarchical Imaginary Science." Journal of Educational Psychology 61.2 (1970): 102-109. (32)

---. "Specific Review Versus Repeated Presentation in a Programmed Imaginary Science." Journal of Educational Psychology 61.5 (1970): 392-399. (31)

Mevarech, Zemira R. "The Effects of Cooperative Mastery Learning Strategies on Mathematics Achievement." Journal of Educational Research 78.6 (Aug. 1985): 372-77. (20)

---. "The Role of Teaching-Learning Strategies and Feedback-Corrective Procedures in Developing Higher Cognitive Achievement." Diss. U. of Chicago, 1980. (35)

Miller, Marvin M. "The Computer and Testing." NASSP Bulletin. February 1970: 41-47. (44)

Niedermeyer, Fred, Jerry Brown, and Bob Sulzen. "Learning and Varying Sequences of Ninth-Grade Mathematics Materials." The Journal of Experimental Education 37.3 (Spring 1969): 61-6. (24)

Popham, W. James, Ed. Evaluation in Education. Berkley: McCutchan Publishing Corporation, 1974. (16)

Powell, George D. "The Use of Mark-Sense Readers in Evaluation." Microfiche/ED 247 269. Paper presented at the Annual Meeting of the American Educational Research Association. New Orleans, April 1984. (44)

Resnick, Lauren B., Margaret C. Wang, and Jerome Kaplan. "Task Analysis in Curriculum Design: A Hierarchically Sequenced Introductory Mathematics Curriculum." Journal of Applied Behavior Analysis 6.4 (Winter 1973): 679-710. (22)

---, Shirley S. Woods, and Guy J. Groen. "An Experimental Test of Five Process Models for Subtraction." Journal of Educational Psychology 67.1 (1975). 17-21. (32)

Resta, Paul F., Joel E. Strandberg, and Edwin Hirsch. "Strategies for Development of Computer-Based Instructional Management Systems." Micro-fiche/ED 046 245. Southwest Regional Educational Laboratory, Inglewood, California. Paper presented at the Annual Meeting of the American Educational Research Association. New York, 1971. (41)

Roe, K. Vlachouli, H. W. Case, and A. Roe. "Scrambled Versus Ordered Sequence in Autoinstructional Programs." Journal of Educational Psychology 53.2 (June 1962): 101-104. (25)

Rollins, Sidney P. "The Coventry, Rhode Island Mastery Learning Project." Education 104.2 (Spring 1979): 120-127. (16)

Sanderson, Herbert W. "Student Attitudes and Willingness to Spend Time in Unit Mastery Learning." Research in the Teaching of English 10.2 (Aug. 1976): 191-98. (33)

Seifert, Edward H., and John J. Beck, Jr. "Relationships Between Task Time and Learning Gains in Secondary Schools." Journal of Educational Research 78.1 (Sept./Oct. 1984): 5-11. (33)

Shale, Douglas and Donald Cowper. "A Computer-Based Support System for Mastery Instruction." Assessment and Evaluation in Higher Education 7.2 (Summer 1982): 167-180. (43)

Stolurow, Lawrence. "Some Factors in the Design of Systems for Computer-Assisted Instruction." Microfiche/ED 033 600. Technical Report No. 7, Office of Naval Research, Contract No. N00014-67-A-0298-0003, Harvard University, Cambridge: Harvard Computing Center, 1968. (41)

Tatsuoka, Kikumi, K., and Maurice M. Tatsuoka. "Spotting Erroneous Rules of Operation by the Individual Consistency Index." Journal of Educational Measurement 20.3 (Fall 1983): 221-30. (39)

Taveggia, Thomas C. "Personalized Instruction: A Summary of Comparative Research, 1967-1974." American Journal of Physics 44.11 (Nov. 1976): 1028-33. (17)

Taylor, Susan S. "The Effects of Mastery, Adaptive Mastery, and Non-Mastery Models on the Learning of a Mathematical Task." Paper presented at the Annual Meeting of the American Educational Research Association. Washington, D.C., March 30-April 3, 1975. Microfiche/ED106 145. (20)

Trembath, Richard J., and Richard T. White. "Mastery Achievement of Intellectual Skills." Journal of Experimental Education 47.3 (Spring 1979): 247-252. (25)

Turnbaugh, Roy. "A Successful Program to Improve Student Performance." Microfiche/ED 254 924. Paper presented at the Annual Meeting of the American Educational Research Association as part of "When Worlds Collide: School-University Cooperative Research," a Northwestern University Consortium. New Orleans, April 23-27, 1984. (21)

Webb, Noreen and Joan Herman. "Diagnosing Students' Errors from Their Response Selections in Language Arts." Microfiche/ED 252 556. Report by the Center for the Study of Evaluation, University of California. Los Angeles: November, 1984. (39)

White, Richard T. "The Validation of a Learning Hierarchy." American Educational Research Journal 11.2 (Spring 1974): 121-136. (27)

---, and Richard E. Mayer. "Understanding Intellectual Skills." Instructional Science 9 (1980): 101-127. (22)